stands in the way of a discussion at length. The bureau's general conclusions in their most conservative aspect can not be better expressed than in the words of Mr. Marvin in the paragraph beginning on page 500 "The present writer is of the opinion," and ending * * * "rather than aperiodic, as he concludes," of his paper attached, wherein he concludes, practically, that De Blois' proposition is not proved. With the whole of Mr. Marvin's paper the bureau concurs, and especially with the ingenious suggestion as to the possibility of *something* in the nature of "beats" between the oscillating discharge and the vibrating system of the oscillograph.

2. The description of De Blois's experiments leaves the bureau uncertain as to the exact arrangement of apparatus with which the oscillogram in figure 3 [not reproduced from De Blois] was obtained. If this record was obtained from a spark discharge *from the antenna* described on page 564 when excited by the oscillation transformer described on page 570, the bureau would be inclined to believe that his experiments indicate positively the probability of an oscillatory rather than a unidirectional character of lightning discharges.

3. The antenna described is a strong oscillator. De Blois himself speaks of it as having low damping. Its tendency, therefore, upon discharge is to effect this discharge through a long series of oscillations in its own natural period, irrespective of the method of excitation. If excited by impact it follows this tendency without hindrance. A unidirectional lightning flash would appear to afford ideal shock excitation, and since we know that the observed spark from the antenna is oscillatory in such a case the question arises "What is the behavior of the oscillograph under this condition?" This point appears to have been neglected in the experiments, though seemingly it might easily have been investigated by means of ordinary quenched gap excitation. Suppose we have investigated it and have found the oscillograph to give *only sudden definite flicks* like those in figure 3 [not reproduced from De Blois]. How then explain the succession of peaks such as those actually observed, as shown in figure 1 [not reproduced from De Blois]? Obviously either—

(1) As the result of "progressive breakdown" phenomena, described by Steinmetz, in which case the demonstration is still conclusive, or

(2) As the result of forced oscillations of long period or of mixed period, which is the same as saying that the lightning flash is oscillatory.

4. It appears to the bureau that nothing is to be deduced with certainty from this data until the behavior of the oscillograph is known when subjected to oscillatory discharges of different frequency and damping. With an instrument of such low periodicity as 5,000—6,000 too many unknown factors enter to allow a reasonable attempt to interpret the results except in the light of such experimentation.

Bureau of Steam Engineering.

523.4

THE ATMOSPHERE OF THE PLANET MARS.

The subject of the so-called canals on the planet of Mars has been carefully treated in a series of articles by Prof. William H. Pickering, published in Popular Astronomy in 1914. He finds that one may perceive similar canals on the moon if only its surface is examined under the same optical conditions used in the study of Mars. It may be worth while for the meteorologist to study the surface of the earth under similar conditions. He has only to represent on an artificial globe the portions that are water, snow, or ice; mountains, plateaus, or lowland; forests, prairies, or deserts, by a proper system of coloring; then place the globe at the proper distance and view it with the proper magnifying power through an atmosphere that is more or less hazy or undulating. The following extracts from Prof. Pickering's paper will show what could be expected under these conditions:

LUNAR CANALS.

The present report will be devoted chiefly to a study of the canals. By a canal in the astronomical sense of the word is meant any long, narrow dark marking that is straight, or of large radius of curvature and of fairly uniform breadth and density. The existence of the canals on Mars as objective realities must appear obvious to any one who has seen the planet under sufficiently favorable circumstances. They have been seen at this station [Mandeville, Jamaica, W. I.] with the 11-inch refractor by using a magnification of 660 when the diameter of the planet was but 5.6 inches. When well seen they can be held by the eye like any other real marking for indefinite periods. The main cause of the controversy regarding them is that in northern latitudes, where most of the large telescopes are located, the seeing is not sufficiently good to show them well, and their existence therefore continues to be doubted in some quarters.

Another cause of doubt depends on the mistaken idea still held by the public, and also by many astronomers, that the larger the telescope the more you can see with it. If the seeing were good enough, or if the objects were very faint, this would obviously be true. But even with double stars there is a limiting size of aperture giving the best results, depending on the quality of the seeing, and with bright planetary detail this limit is very marked indeed. The statement once made in joke that the 40-inch Yerkes lens is too powerful to show the canals of Mars is literally true. There are too many air waves constantly passing in front of its great surface to permit of the necessary planetary definition.

For our northeastern States the best results on a good night can be obtained with an 8-inch aperture. In the Southwest 16 inches is perhaps the limit. The proper size for the Tropics has not yet been reached by any instrument located there, and is still unknown. Any telescope intended for regular use on planetary detail should be provided with a cat's-eye diaphragm placed over the objective, which can be adjusted instantly from the eye end of the telescope, a device first used I believe at the Lowell Observatory.

As a means of studying the canals of Mars it occurred to the writer that since the moon is a body closely resembling it, and of the same order of size, if we were to apply to it the same magnification in proportion to its distance, that we might get a similar effect. The average distance of Mars at opposition is 50,000,000 miles, the average distance of the moon, one-quarter of a million. The moon being at one two-hundredths the distance of Mars, we should use one two-hundredths the magnification. The Martian canals are well seen with a power of 500. An ordinary opera glass giving a power of 2.5 would therefore be a proper instrument with which to view the moon. If we wish to have the moon appear of the same size as Mars, a field glass magnifying five times should be employed.

A preliminary sketch made with an opera glass on April 28, 1912, showed a number of long, narrow canals crossing the face of the moon. Of these the most conspicuous was the broad, double canal shown in figure 1 [not here reproduced] extending northwesterly from Tycho. Next came the three canals to the west of it and a few of those shown in Imbrium. All were narrow and quite uniform in appearance. The present sketch was made with a field glass magnifying four times, on October 14, 1913, colongitude 90°. The double canal extending from Tycho was now so broad that it had almost lost its canal-like character, but numerous fine canals appeared, among them several exceeding 400 miles in length. Only the more conspicuous ones have been drawn, in order to avoid confusing the sketch. When near the terminator the canals are faint or invisible. They seem to be most conspicuous when the moon is full, and individually to vary more or less with the colongitude. It would seem as if a detailed study of them might repay the careful observer. Perhaps the best results are obtained on a slightly hazy evening or with the moon not very far above the horizon, so it shall not be too dazzling. Even with an opera glass better results are obtained if it is steadied by holding it against a post. It is perhaps easier to see them in the first place with a field glass, but once seen, an opera glass gives them a more canal-like appearance. With the latter they are narrow, straight, and gray or black; with the former they show a slightly irregular structure, and at times are distinctly brownish. There are few canals on Mars more distinct than those between Copernicus and Aristarchus when seen under favorable conditions with an opera glass.

But it is not necessary to wait for a moonlight evening in order to see the lunar canal. The same result can be obtained, though in an inferior way, from any good photograph of the full moon. This should be placed against the wall in a strong light and viewed with the naked eye from a distance of between 20 and 40 times its diameter. If we get nearer than this we see that the lakes, with the exception of Plato, are not sharply defined regions, but simply small, dark areas of irregular shape and density, which are in reality much larger than they appear in the drawing. Similarly the canals, which are drawn as heavy, fine lines, are in reality broader and less intense areas of the same length. They vary in general from 20 to 60 miles in breadth. The effect is clearly not due to areas of irregularly distributed and imperfectly seen fine detail. The surface is not necessarily irregular in density nor spotted nor filled with any detail at all. All that is required to produce a canal is a comparatively slight difference in density, a reasonable breadth, and a sufficient intrinsic brilliancy to render it visible. * * *

A study of the lunar canals calls to our attention an unlooked-for characteristic. We should naturally expect that as we approached nearer and nearer to the photograph, or used higher and higher powers upon the moon, that while the canals first seen would be resolved and exhibited in their true aspect, that other finer canals would appear which a closer approach would in their turn resolve. On the moon, excepting with very low powers, this does not seem to be the case. It is true that with a power of several hundred diameters, short, uniform canals make their appearances, resembling in all respects the short, stout canals in the Solis Lacus region of Mars (Harvard Annals, 53:75), but the long, narrow canals hundreds of miles in length, so characteristic of Mars, are seen on the moon only with such low powers as we have just described. It must be noted that in the case of these canals their size and appearance do not vary in any way with the aperture, but only with the magnification. Of this anyone can readily satisfy himself.

As we reduce the aperture of the field glass, a slight improvement in distinctness is noted when we reach a size of about one-fourth inch, on account of the reduction of the glare, but when the aperture gets below one-eighth or a magnification of 32 to the inch, they become less distinct again. They continue to remain visible and to be of the same breadth and in the same place until with failing light they gradually fade from view. * * *

The surface of Mars appears to be particularly well adapted to producing the canal effect. Only isolated areas upon the moon show it to advantage. This may be because the bright areas of the moon are too rough and the smooth areas too dark—for even on Mars the canal effect is conspicuous only in the bright regions. Again, on account of the more abundant vegetation on Mars, it is possible that stripes on the planet are more frequent, for it must be remembered that the basis of every canal is really a stripe, although the increase of blackness may be slight and the breadth great and irregular. The presence of lakes at the two ends of a canal will render it much more readily visible, though they will not produce a canal if there is no real shading between them. It might be suggested that a new and temporary canal on Mars might appear in any region if bounded on either side by a faint band of haze or cloud. At every opposition, by using the proper magnification, 300 to 600, some canals should be seen, and if they are not it merely indicates that the definition is inferior. The better the definition, quite regardless of the aperture of the telescope, the more clearly will the canals appear.

In our sketch of the moon the shape and location of the maria, and the positions of a considerable number of the bright craters are in fair agreement with what we know to be the case, as based on photographs and the use of higher telescopic powers. To the left and above the center of our figure, shaped like a letter F, are several short, thick canals and a number of lakes which are also in fair agreement with the facts. On the other hand, our long, thin canals give little or no information as to the real appearance of that portion of the surface. In spite of this fact the canals of Mars are well worth while observing, because they change with the seasons and also differ from year to year at the same season on Mars. This is perhaps the most artificial feature. If the observer desires to study them to the best advantage, then the only way to do so is to draw them as they appear. Sometimes many of them appear as straight, narrow, dark lines. The fact that they may not really be narrow or perfectly regular is no reason why they should not be carefully studied and named, and all honor should be given to Schiaparelli, who, although not their discoverer, was the first to observe them in large numbers and to draw general attention to their existence. Still, we must remember at their best they are only indications of detail, not the real thing. That is to say, what they indicate is something that is actually beyond the power of the observer's telescope to correctly define. * * *

The most striking difference between the lunar and Martian canals is that the latter are much more variable both in density and position, and often are entirely invisible. The former vary a little in density with the colongitude, which corresponds with the season upon the moon. Those lunar canals visible with a field glass we shall designate as the coarser canals; those visible in the telescope we shall call the finer ones. With the latter we have the same difficulty as in the case of Mars, they appear perfectly straight and uniform, and as we saw in our last report, in some cases they may even appear double. * * *

CONCLUSIONS.

It now only remains for us to draw whatever conclusions may seem probable with regard to these interesting objects, since it does not seem likely that any further light on their nature will be gained, at least as far as Mars is concerned, before the next opposition. It is believed that Lambert was the first to suggest that the reddish areas of Mars owed their color to vegetation. The suggestion that they were simply desert regions, while the dark areas and canals were due to vegetation instead of water, was of comparatively recent origin.[1]

The writer believes that both types of lunar, as well as the Martian canals, are due to vegetation. Indeed, no other explanation seems possible when we stop to consider the facts. It does not seem possible that the lunar canals can be artificial, but the Martian ones act differently from them in some respects, notably in their great variability, and if we may so express it, their apparently unnatural conduct, some appearing during one Martian year and others during another, at the same season. They act, indeed, almost as if there were some guiding intelligence behind them. Their uniform breadth, straightness, and occasional circular or elliptical forms are waived as arguments, because perhaps they are not really quite as regular as they appear, and because we find something very similar upon the moon. It is to their changes that we should especially direct our attention, and regarding which future observers should secure all possible data.

The Martian atmosphere, as far as its permanent constituents are concerned, we know to be more or less rarefied. The amount of water vapor it contains on the other hand, in the presence of ice or water, depends exclusively upon the temperature. When the polar caps are melting rapidly therefore, and large liquid surfaces present themselves in the marshes, the atmosphere may, at ordinary terrestrial temperatures, be composed in a very large part of water vapor. At other times it may contain very little. The question of the Martian seasons should be considered very carefully in any future attempts to detect the presence of water vapor by means of the spectroscope. One of the most careful and painstaking attempts hitherto made to secure evidence of the presence of water vapor upon Mars was made during the dry season upon the planet.

Assuming that the canals are due to vegetation, we must further assume either that they are or are not artificial. Assuming first that they are, we shall find that three attempts have hitherto been made to explain them.

(*a*) They were formerly supposed to be fertilized by invisible irrigating ditches or conduits. The difficulty with this idea is to maintain the necessary circulation of water. Prof. Lowell, when he adopted it, suggested that the circulation was maintained by pumping. To this it is replied that that would require altogether too great an expenditure of energy when the problem is reduced to figures. Indeed, the formation of the polar caps is sufficient of itself, as Prof. Douglass long ago pointed out, to show that the planetary circulation must be in large part atmospheric and not due, except at the very beginning, to artificial canals. If it is atmospheric in part it might as well be wholly so.

(*b*) It was suggested a few years ago [2] that the canals consisted simply of a growth of dark vegetation like trees or bushes upon grassy or semiarid plains of a lighter color, all being supported by water derived from the natural aerial circulation of the planet. The beauty of this plan consists in its extreme simplicity, and the fact that such canals actually exist upon the earth on a small scale, constructed in this matter for good and sufficient reasons, though presumably not the same ones, namely protection for herds of cattle against winter storms. The difficulty, however, is to account for the shifting of the canals.

(*c*) In an atmosphere saturated with moisture, fogs should readily form at night, which would disappear to a large extent in the daytime. This frequently occurs at certain seasons, notably the early autumn, upon the earth. Since the surface of Mars seems to be extremely flat, it is suggested that these fogs instead of being permitted to exhibit a general accidental distribution, might be localized night after night in certain selected regions artificially. It is known as a laboratory experiment that fog can be induced to form in a saturated atmosphere if furnished with a sufficient number of minute solid nuclei on which it may condense. It is suggested that it might be practical to do this, either by electrifying the air in certain regions night after night, or by some such similar means upon a large scale on Mars. Where the fogs condensed at night vegetation would appear by daylight, when the fog cleared away. As a matter of observation, fog is often seen on the sunrise limb of the planet, and it does in general clear away as the sun rises higher upon it. Occasionally, however, it persists throughout the day, particularly near the northern boundary of certain dark areas, such as Sabaeus and Cerberus, as noted in our Report No. 3. A certain shifting of the fertilized areas from time to time would doubtless insure improved crops if the water supply were insufficient to fertilize the whole, so that we can readily see an object for it. If, on account of accelerated growth due to greater moisture, the vegetation ripened, dried up, and died first along the medial line of the canal, we can account for the apparent duplications sometimes observed. In our Report No. 4 we saw that marshes did actually appear to advance and change their positions in this manner, following clouds or fogs produced by evaporation from their surfaces.

The difficulty with this explanation is the question whether it would be possible in a saturated atmosphere overlying a uniform surface, to select any locality at will over which a fog should be produced.

Assuming now that the canals are due either to vegetation or to any other cause, but that they are *not* artificial, we find that to frame a plausible hypothesis that will explain the changes hitherto observed is a matter of extreme difficulty. The only natural agencies at our disposal capable of producing such changes seem to be either volcanic or meteorological. The latter appears to be the more promising, although many of the lunar canals lie along volcanic cracks. We may modify either (*b*) or (*c*) by substituting for intelligent design the accidental shifting of the winds, bringing more moisture and causing certain kinds of vegetation to flourish. To support a single canal 2,000 miles long by 500 miles wide would seem to require too much volcanic activity. Such suggestions involve added hypothesis and are, therefore, unsatisfactory. It may fairly be said that no satisfactory explanation,

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[1] Science, 1888, 12: 82.

[2] Harper's Monthly Magazine, 1908, p. 192.

based on purely natural causes, has as yet been suggested to account for the changes observed on Mars.

It is not considered by the writer, however, that any of these hypotheses are sufficiently well supported as yet to justify us in such a momentous conclusion as the decision that intelligent animal life now exists upon Mars. To the majority of scientific men, probably nothing short of the reception of a series of intelligible signals would be considered sufficient evidence to lead to such a decision. These theories of the canals are mentioned here, not because the writer feels assured that any one of them is right, but simply because (*b*) and (*c*), at least seem to him to account for the observed facts more readily than any of the others, and because he feels that any theory, even a false one, is better than none at all. To the direct question so often asked, however, "Is Mars inhabited by intelligent beings?" we must, and probably long shall be obliged to reply simply, possible, but not proven.

DOES THE DARKEST HOUR COME JUST BEFORE DAWN?

This popular saying is frequently supposed to be poetical rather than meteorological. The well-known observer of meteors, Mr. W. F. Denning of Liverpool, in a note to The Observatory, as quoted in the Journal of the Royal Astronomical Society of Canada,[1] states that his own experience would confirm the truth of this proverb, and we quote his statement in full in the hope that American observers may throw light on the problem.

The darkest hour precedes the dawn.—I have occasionally seen inquiries as to the truth of this expression, but can not remember to have read any discussion or explanation of the subject.

Having been out observing on thousands of nights, and often enough "until the dappled dawn" rose, I may, perhaps, be allowed to give an opinion on the matter—and it is certainly in favor of the view stated in the heading to this note. I have frequently been impressed with the intense darkness which comes on before dawn. When a person has been out all night his eye naturally becomes accustomed to the prevailing conditions; he can discern things with astonishing distinctness and is familiar with such objects around as are within his range of vision.

Before dawn a greater darkness seems to drop down like a mantle upon the *immediate surroundings*. Objects which were plainly observable during the previous hours of the night are blotted out, and a nervous feeling is sometimes induced by the dense opacity of the air. I think the unusual darkness only lasts a short time, and that a quick brightening succeeds, but its occurrence is most marked and by no means a rare experience. I have noticed it independently of any previous knowledge, and when such a thing has been far from my thoughts, so it can not have been a subjective sensation. But I have been out only on clear, starry nights.

I regret that I have recorded no observations in detail, and so can not say the exact interval before sunrise when the remarkable darkness came on, and whether it is common to every night and season and condition of sky. But of its frequent manifestation I can speak with confidence, and possibly there may be some simple explanation of the event, though it does not occur to me at the moment.

NOTES ON BALLOON OBSERVATIONS AND ON WATERSPOUTS FROM THE VOYAGE OF LA PÉROUSE.

In the MONTHLY WEATHER REVIEW for October, 1898, **26**: 461–463, we have published all known references to the use of the kite, but Dr. Otto Klotz has sent us from Ottawa a note that is worth repeating from the original French text.

In the original Paris edition,[2] "Voyage de la Pérouse au Tour du Monde," v. 1, Paris, 1797, there have been collected in four quarto volumes all that pertains to the unfortunate expedition which started June, 1785, and was destroyed by a hurricane in 1788 among the islands northwest of Australia.

[1] Toronto, July–August, 1914, **8**: 294–295.

[2] Published in accordance with the decree of Apr. 22, 1791, and edited by L. A. Millet-Mereau.

These four volumes embrace the personnel of those under La Pérouse, also the detailed orders of the King, Louis XVI, relative to the route of the expedition. Among the special observations relative to navigation those relating to the magnetic needle were prominent. Beginning with volume 1, page 156, of the quarto French edition of 1797 (or p. 222 of the octavo English edition of 1798) are given in detail the scientific objects suggested by the Academie des Sciences, as communicated by its eminent permanent secretary, De Condorcet, who was born in 1742 and died in 1794, a sacrifice to the troubles of that year.

Among the apparatus of the scientific outfit we note (p. 249, 1797 edition): "One large balloon of toile [either linen or cotton cloth] with an inner lining of thin paper (papier Joseph), 26 feet high and 22½ feet in diameter; also three balloons of paper and three of goldbeaters' skin." This outfit having been provided in 1785 seems to have contemplated the use of hydrogen gas, which was advocated for aeronautic use by the Paris Academy of Sciences in 1783, as being better than the Montgolfier [method], although the popularity of the latter had captivated the attention of all the world.

We translate as follows (p. 162, French edition; p. 122, English edition of 1799) from the suggestions by the Academy of Sciences:

The academy on learning that the navigators are carrying with them a certain number of small aerostatic balloons invites them to make use of these in order to determine the altitude at which the winds that blow in the lower part of the atmosphere change their direction and also the course of these directions. These observations are especially important in localities where the trade wind prevails, where it will be desirable to know its relation with the winds of the upper region of the atmosphere * * *.

On page 163, we read:

There is no agreement as to the cause that produces waterspouts (trombes) or tornadoes; some attribute them to electricity; others consider them as the effect of a turbination (twisting ascent) contracted by a mass of air.*

Navigators should be very attentive to observations of all the circumstances that conduce to the explanation of this mysterious phenomenon.

* In this latter hypothesis the centrifugal force of molecules of air forced from the axis of rotation should diminish the pressure of those that are located near the axis, forcing them to relinquish the water they hold in solution and to give rise to a cloud whose form will be very nearly that of a solid of revolution and whose little drops will soon disperse as the *effect of centrifugal force. The pressure of atmospheric air not being* diminished in the direction of the axis of rotation, the air should perpetually renew itself, entering at the two extremities of the axis and by the diminution of pressure maintain in the interior a continuous precipitation of water that will endure as long as the turbinate movement continues and whose abundance will depend on the velocity of that movement and of the mass of air it affects.

This theory of the form and action of waterspouts is in many of its details so far in advance of anything that had been advocated by Andoque (1727); Franklin (1753); Cotte (1774), and others of that time, that we may properly attribute it to the distinguished permanent secretary of the Academy, Condorcet, whose thorough familiarity with the laws of mechanics expounded by Euler and whose remarkable insight into every branch of natural philosophy seems to warrant and justify our conclusion. Had not d'Alembert died in October, 1783, we should have thought this lucid explanation might have emanated from that distinguished philosopher. Doubtless the mechanics of tornadoes as we now understand it had been most carefully discussed by those eminent members of the Academy of Sciences, Condorcet, d'Alembert, La Place, and Benjamin Franklin who frequently attended its meetings during the years 1776–1785.—[C. A.]